

Cross-sectional and prospective association between internet addiction and risk of fatigue among Chinese college students

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Abstract

Severe internet addiction (IA) is associated with a higher risk of musculoskeletal pain, but whether there is a significant prospective association between IA and fatigue is unclear. This study aimed to examine the association between IA and fatigue level among Chinese college students. A cross-sectional ($n = 1011$) and prospective study ($n = 653$) was conducted to examine the association between IA and risk of fatigue. IA was measured using Young internet addiction test. Fatigue level was evaluated using the Chalder fatigue scale. Multivariate logistic regression analyses showed a cross-sectional association between IA and the risk of fatigue. The odds ratios (95% CIs) of fatigue for normal, mild, and moderate to severe groups were 1.00 (reference), 1.88 (1.20, 2.95), and 5.60 (3.33, 9.42), respectively (P for trend: <0.001). Similarly, multivariate logistic regression analyses also revealed a significant prospective relationship between IA and the risk of fatigue during the 1-year follow-up period. The odds ratios (95% CIs) of fatigue for normal, mild, and moderate to severe groups were 1.00 (reference), 1.56 (0.67, 3.67), and 3.29 (1.08, 10.04), respectively (P for trend: 0.046). Our findings indicate that IA is positively related to risk of fatigue among Chinese college students. Further interventional studies are needed to explore the causality underlying the effects of IA on fatigue.

Abbreviations: ANCOVA = analysis of covariance, BMI = body mass index, CFS = Chalder fatigue scale, CI = confidence interval, CNVCPFH = Chongqing Nursing Vocational College Physical Fitness and Health, IA = internet addiction, IAT = internet addiction test, SDS = Self-Rating Depression Scale.

Keywords: college students, fatigue, internet addiction

1. Introduction

Fatigue is defined as a complex of physical and mental symptoms characterized by an overwhelming sense of tiredness, lack of energy, and a feeling of exhaustion, associated with impaired physical and/or cognitive functioning.^[1] In different populations, the prevalence of fatigue showed different trends, with a rate of 28.0% in Japanese,^[2] 55.2% in Korean,^[3] and 10.7% in Chinese adults.^[4] Similarly, a relatively high prevalence of fatigue was also reported in adolescents. For example, in East Asian adolescents, the prevalence of fatigue ranged from 1.6% in Korea^[5] to 16.5% in Japan,^[6] while Chinese adolescents showed substantially higher prevalence rate at 67.3%.^[7] Although fatigue is a suboptimal health status between health and disease,^[8] previous studies have indicated that exposure to long-term fatigue is associated not only with poor quality of life^[9] and work productivity^[10] but also with ischemic heart disease and stroke-induced death.^[11] Thus, it is essential to identify the risk factors for fatigue to develop an effective preventive strategy.

The convenience and entertainment access brought about by the widespread use of computer networks have led people

to use them more frequently. Consequently, in recent years, an increasing number of individuals have been addicted to internet use. Indeed, a meta-analysis of 113 epidemiologic studies including 693,306 individuals showed that the average prevalence of internet addiction (IA) was 7.02%, and it increased over time.^[12] IA prevalence was higher in East Asian countries than in Western countries.^[12] In addition, findings from large-scale nationwide investigations and meta-analysis in East Asian countries showed high prevalence of IA, for instance, 8.1% among the Japanese^[13] and 12.5% among the South Korean adolescents.^[14] This prevalence rate of IA was close to the value in studies evaluating Chinese adolescents (11.3%).^[15] Moreover, our prior study found that IA was associated with a higher risk of musculoskeletal pain^[16] because excessive internet use, which was considered sedentary behavior, could raise systematic inflammation,^[17] thus subsequently increasing musculoskeletal hyperalgesia.^[18] Although musculoskeletal pain is a distinctive feature of fatigue, whether there is a significant association between IA and fatigue is a topic worthy of investigation. In other words, it is necessary to further explore the association between IA and the risk of fatigue.^[19–21] Because

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these results lack replication in Chinese population-based studies, we designed a cross-sectional and prospective study to examine the association between IA and fatigue level among Chinese college students.

2. Participants and Methods

2.1. Study participants

This study originated from the Chongqing Nursing Vocational College Physical Fitness and Health (CNVCPFH) study, which was carried out at Chongqing Nursing Vocational College in Chongqing, China, and aimed to examine the association between the health-related physical fitness level and the health status of college students. The Chongqing Nursing Vocational College, which includes 6 disciplinary categories (nursing science, midwifery, rehabilitation, aged people service and administration, community-based rehabilitation, and rehabilitation of traditional Chinese medicine), is the only nursing university in the municipality of Chongqing.^[22]

In the first week of October 2018, we invited all 1094 of their freshmen population to participate in this study during their annual physical fitness measurement. All agreed to participate and provided written informed consent for the use of their data, either by themselves or with the consent of their legal guardians. All participants were asked to complete a self-designed survey questionnaire including demographic data (e.g., sex, age, father's and mother's educational level, parents' marital status), lifestyle factors (e.g., breakfast frequency, smoking and drinking habits, and physical activity, sleep duration, sleep quality, and internet addiction), presence of depressive symptoms and fatigue. Eighty-three participants with missing information on lifestyle factors were excluded at baseline. During the 1-year follow-up period, we excluded 191 participants with existing fatigue at baseline and 167 participants with missing data on other variables. Finally, this study analyzed 1011 participants at baseline and 653 participants during the 1-year follow-up period. Ethics approval was obtained from the Institutional Review Board of the College of Physical Education of Southwest University.

2.2. Assessment of IA

Young internet addiction test (IAT) was used to assess the participants' IA levels.^[23] The IAT allowed the gathering of data on the participants' internet usage habits, their thoughts about the Internet, and the impact of internet usage on their lives. The IAT consists of 20 items, each scored on a 5-point scale (1 = "not at all" to 5 = "always"), and the scores of all the items were summed. A higher score represents more severe addiction. Three cutoff points were used to differentiate internet addiction status: normal (0–30 points), mild (31–49 points), and moderate to severe (50–100 points). The Chinese version of the IAT has been shown to have good reliability and validity.^[24] Cronbach α coefficient was used to evaluate internal consistency and reliability, and the results indicated that the internal reliability of the IAT was good (Cronbach α coefficient: 0.927).

2.3. Assessment of fatigue

Fatigue level was assessed using the 11-item version of Chalder fatigue scale (CFS).^[25] The CFS asked the participants to answer all 11 items with a number ranging from 0 (better than usual) to 3 (no more than usual). The scores of all items were summed to generate the total score. A higher score represents a more severe fatigue level. To define fatigue status, we dichotomize with responses "0" and "1" having scores of 0 and "2" and "3" a score of 1. A total fatigue score range from

0 to 11 and a fatigue score of ≥ 4 to define fatigue cases. The Chinese version of the CFS was shown to have good reliability and validity.^[26] Cronbach α coefficient was used to evaluate internal consistency and reliability, and the results indicated that the internal reliability of the CFS was good (Cronbach α coefficient: 0.866).

2.4. Relevant covariates

Demographic characteristics included sex and age (continuous variables) and lifestyles factors including breakfast consumption frequency (≤ 1 time/week, 2–5 times/week, or ≥ 6 times/week), smoking status (never, occasionally, or regularly), drinking status (never, occasionally, or regularly), and sleep duration (continuous variable) and quality (good or not). This study assessed the depressive status of participants using the Chinese version of the Self-Rating Depression Scale (SDS).^[27] The SDS includes 10 positive and 10 negative items, with 4 answer options (none, some of the time, most of the time, or all of the time), and each item is scored from 1 to 4. The scores of all items were summed to produce the total score, where a higher score represents a more severe depressive status. This study defined a participant with an SDS score of ≥ 50 as having depressive symptoms. Additionally, we measured the height and weight of the participants using standard protocols and computed their body mass index (BMI, continuous variable).

2.5. Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics 24.0 (IBM SPSS Inc., Chicago, IL). Continuous variables are expressed as mean \pm SD or mean (95% confidence interval [CI]), and categorical variables are expressed as percentages (95% CI). For the participants' characteristics, analysis of variance was applied to compare the categories of IA.

Because the fatigue variable did not have a normal distribution, natural logarithm was used to normalize it for multivariate statistical analyses. Analysis of covariance (ANCOVA) was applied to analyze the association between IA categories and fatigue level after adjustment for sex and age (continuous variable) in Model 1. Model 2 was further adjusted for smoking status (never, occasionally, or regularly), drinking status (never, occasionally, or regularly), sleep quality (good or not), sleep duration (continuous variable), and BMI (continuous variable). Model 3 was further adjusted for depressive symptoms. Lastly, Model 4 was further adjusted for breakfast consumption frequency. Similarly, multivariate logistic regression analyses were used to examine the association between IA and the risk of fatigue using the above-mentioned 4 models. Statistical significance was set at $P < .05$.

3. Results

The participants' characteristics according to the IA categories are presented in Table 1. Compared with participants with normal IA levels, participants with mild and moderate to severe fatigue levels had stronger drinking habits (P for trend: <0.001), shorter sleep duration, worse sleep quality, and more depressive symptoms (all P for trend: <0.001). Furthermore, the IA categories were inversely associated with breakfast consumption frequency. There were no other significant differences between the IA categories.

This study used ANCOVA to analyze whether the IA categories were positively associated with fatigue level. Table 2 shows that there was a positive and significant association between IA and fatigue level after adjustment for potential confounders at baseline. The geometric means (95% CIs) of the total fatigue level for normal, mild, and moderate to severe groups were 3.3 (2.4, 4.5), 8.4 (6.6, 10.8) and 14.8

Table 1
Participants' characteristics according to IA categories*

N = 1011	Total	Normal (n = 329)	Mild (n = 533)	Moderate to severe (n = 149)	P-value†
IA score	37.3 ± 12.2	25.5 ± 3.3	38.5 ± 5.2	59.1 ± 9.9	—
Female sex, %	90.0	90.0	90.1	89.9	0.998
Age, yr	18.7 ± 1.0	18.7 (18.6, 18.8)	18.6 (18.5, 18.7)	18.6 (18.4, 18.7)	0.690
BMI, kg/m ²	21.0 ± 4.8	20.8 (20.3, 21.3)	21.1 (20.7, 21.5)	21.3 (20.5, 22.2)	0.533
Smoking status, %					
Never	92.8	92.4 (89.5, 95.3)	93.6 (91.5, 95.7)	90.6 (85.9, 95.3)	0.431
Occasionally or regularly	7.2	7.6 (4.7, 10.5)	6.4 (4.3, 8.5)	9.4 (4.7, 14.1)	
Drinking status, %					
Never	45.5	54.1 (48.8, 59.5)	42.6 (38.4, 46.8)	36.9 (29.0, 44.9)	<0.001
Occasionally or regularly	54.5	45.9 (40.5, 51.3)	57.4 (53.2, 61.6)	63.1 (55.3, 70.9)	
Sleep duration, hr	6.7 ± 1.1	6.9 (6.8, 7.0)	6.6 (6.5, 6.7)	6.3 (6.2, 6.5)	<0.001
Good sleep quality, %	75.8	82.7 (78.6, 86.8)	75.4 (71.8, 79.1)	61.7 (53.9, 69.6)	<0.001
Depressive symptoms (≥50), %	10.6	8.8 (5.6, 12.1)	7.5 (4.9, 10.1)	25.5 (20.7, 30.4)	<0.001
Breakfast consumption frequency, %					
2–5 times/week	41.3	33.1 (27.8, 38.4)	44.7 (40.5, 48.8)	47.7 (39.8, 55.5)	0.003
≥6 times/week	54.4	63.5 (58.2, 68.9)	50.8 (46.6, 55.0)	47.0 (39.0, 54.9)	0.001

BMI = body mass index, CI = confidence interval, IA = internet addiction, SD = standard deviation.
 *Continuous variables are expressed as mean ± SD or mean (95% CI), and categorical variables are expressed as percentages (95% CI).
 †Analysis of variance or chi-square test for continuous or categorical variables, respectively.

Table 2
Adjusted associations between IA and fatigue level at baseline.

N = 1011	Normal (n = 329)	Mild (n = 533)	Moderate to severe (n = 149)	P for trend*
Model 1†	3.1 (2.2, 4.2)¶	8.7 (6.8, 11.2)	15.2 (9.5, 24.3)	<0.001
Model 2‡	3.3 (2.4, 4.6)	8.6 (6.7, 11.0)	13.5 (8.4, 21.7)	<0.001
Model 3§	3.3 (2.4, 4.5)	8.4 (6.6, 10.8)	14.8 (9.2, 24.0)	<0.001
Model 4	3.3 (2.4, 4.5)	8.4 (6.6, 10.8)	14.8 (9.2, 24.0)	<0.001

*P for trend was obtained using ANCOVA.
 †Model 1 adjusted for sex and age (continuous variable).
 ‡Model 2 adjusted for Model 1 covariates + smoking status (never, occasionally, or regularly), drinking status (never, occasionally, or regularly), sleep quality (good or not), sleep duration (continuous variable), and BMI (continuous variable).
 §Model 3 adjusted for Model 2 covariates + depressive symptoms (categorical variable).
 ||Model 4 adjusted for Model 3 covariates + breakfast consumption frequency (≤1 time/week, 2–5 times/week, ≥6 times/week).
 ¶Adjusted data are expressed as estimated geometric means (95%CI).

Table 3
Adjusted associations between IA and risk of fatigue at baseline.

N = 1011	Normal (n = 329)	Mild (n = 533)	Moderate to severe (n = 149)	P for trend*
Number of fatigue	31	93	67	—
CrudeModel	1.00 (reference)	2.03 (1.32, 3.13)¶	7.85 (4.81, 12.83)	<0.001
Model 1†	1.00 (reference)	2.03 (1.32, 3.12)	7.83 (4.79, 12.79)	<0.001
Model 2‡	1.00 (reference)	1.84 (1.18, 2.86)	6.28 (3.78, 10.45)	<0.001
Model 3§	1.00 (reference)	1.93 (1.23, 3.03)	5.73 (3.42, 9.62)	<0.001
Model 4	1.00 (reference)	1.88 (1.20, 2.95)	5.60 (3.33, 9.42)	<0.001

*P for trend was obtained using multivariate logistic regression analyses.
 †Model 1 adjusted for sex and age (continuous variable).
 ‡Model 2 adjusted for Model 1 covariates + smoking status (never, occasionally, or regularly), drinking status (never, occasionally, or regularly), sleep quality (good or not), sleep duration (continuous variable), and BMI (continuous variable).
 §Model 3 adjusted for Model 2 covariates + depressive symptoms (categorical variable).
 ||Model 4 adjusted for Model 3 covariates + breakfast consumption frequency (≤1 time/week, 2–5 times/week, ≥6 times/week).
 ¶Adjusted data are expressed as odds ratio (95% confidence interval).

(9.2, 24.0), respectively (P for trend: <0.001). Meanwhile, multivariate logistic regression analyses showed a cross-sectional association between IA and the risk of fatigue. The odds ratios (95% CIs) of fatigue for normal, mild, and moderate to severe groups were 1.00 (reference), 1.88 (1.20, 2.95), and 5.60 (3.33, 9.42), respectively (P for trend: <0.001) (Table 3). Similarly, multivariate logistic regressions analysis also revealed a significant prospective relationship between IA and the risk of fatigue. The odds ratios (95% CIs) of fatigue for normal, mild, and moderate to severe groups were 1.00

(reference), 1.56 (0.67, 3.67), and 3.29 (1.08, 10.04), respectively (P for trend: 0.046) (Table 4).

When compared with participants excluded from our analysis [see Supplemental Digital Content (Appendix Table 1, <http://links.lww.com/MD/H35>)], the participants included in the analysis had lower BMI and lower proportion of female sex. We also analyzed change on internet addiction at baseline and follow-up, in which percentage of internet addiction had decreased trend [see Supplemental Digital Content (Appendix Table 2, <http://links.lww.com/MD/H36>)].

Table 4
Adjusted associations between IA and risk of fatigue during the 1-year follow-up period.

N = 653	Normal (n = 242)	Mild (n = 346)	Moderate to severe (n = 65)	P for trend*
Number of fatigue	9	18	7	—
CrudeModel	1.00 (reference)	1.42 (0.63, 3.22)¶	3.13 (1.12, 8.74)	0.045
Model 1†	1.00 (reference)	1.39 (0.61, 3.17)	3.22 (1.14, 9.05)	0.044
Model 2‡	1.00 (reference)	1.59 (0.68, 3.71)	3.48 (1.16, 10.44)	0.034
Model 3§	1.00 (reference)	1.61 (0.69, 3.75)	3.36 (1.11, 10.23)	0.040
Model 4	1.00 (reference)	1.56 (0.67, 3.67)	3.29 (1.08, 10.04)	0.046

†Model 1 adjusted for sex and age (continuous variable) at baseline.

‡Model 2 adjusted for Model 1 covariates + smoking status (never, occasionally, or regularly), drinking status (never, occasionally, or regularly), sleep quality (good or not), sleep duration (continuous variable) and BMI (continuous variable).

§Model 3 adjusted for Model 2 covariates + depressive symptoms (categorical variable) at baseline.

||Model 4 adjusted for Model 3 covariates + breakfast consumption frequency (≤ 1 time/week, 2–5 times/week, ≥ 6 times/week) at baseline.

¶Adjusted data are expressed as odds ratio (95% confidence interval).

*P for trend values were obtained using multivariate logistic regression analyses.

4. Discussion

This study examined the cross-sectional and prospective association between IA and risk of fatigue among Chinese college students. The results showed that the IA level was significantly and positively associated with the risk of fatigue after adjusting for potential confounders.

The results of this study are consistent with those of previous cross-sectional studies, which showed a positive association between internet usage duration^[28–32] or IA^[16] and musculoskeletal pain. Similarly, a significant and positive association between IA and fatigue was shown among adolescents and nurses.^[19–21] Compared with those studies, this study first examined the prospective association between IA and risk of fatigue in a Chinese adolescent population.

Although the exact mechanisms of fatigue development remain unclear, inflammation has been confirmed to play an important role. Several general population-based studies on younger adults found positive associations between inflammatory cytokines, such as C-reactive protein^[33–36] and interleukin-6,^[36] and fatigue level. Inflammatory cytokines can stimulate the central nervous system to produce health-compromising behaviors via neural and humoral pathways through the vagus nerve and the part of the brain with a weak blood–brain barrier, respectively. These then induce modification of neurotransmitters, neuroendocrine systems, and brain function, subsequently causing changes in behaviors (depressive mood, cognitive function decline, fatigue, etc.).^[37] Among these behavioral aspects, fatigue states are more sensitive to inflammatory cytokines than depressive mood and cognitive function decline.^[38] IA promotes inflammation also via the intake of inflammatory food. Indeed, a previous study demonstrated a linear correlation between IA level and the intake of proinflammatory food^[39] containing abundant proinflammatory nutrients, such as trans fatty acids and sodium.^[40] However, this study did not collect information regarding dietary intake. Future studies are needed to further explore the role of proinflammatory food intake in the association between IA and inflammation. However, the association between severe IA and higher fatigue levels remained significant after adjustment for breakfast consumption frequency. Since regular breakfast eaters were shown to have lower dietary inflammatory levels,^[41] we concluded that the significant association between severe IA and higher fatigue level was independent of breakfast consumption.

Additionally, IA had adverse effects on the fatigue level. According to its definition, fatigue can be categorized as physical and mental fatigue, with musculoskeletal fatigue and negative moods being their main manifestations, respectively.^[42] Our previous study that investigated the association between IA and musculoskeletal pain among Chinese young adults indicated that a severe IA status was associated with a higher risk

of musculoskeletal pain.^[16] In China, individuals with more severe IA levels may have used the internet for longer durations. The duration of their internet usage may have accumulated by chatting with friends on WeChat or QQ software or by playing mobile or computer games. Individuals with more severe IA levels often remain in a fixed position for a long time while holding their smartphones or, more generally, show sedentary behavior. Prolonged incorrect postures can induce strain on the muscles, tendons, and disks, which raised systematic inflammation level,^[43] and subsequently lead to hyperalgesia in musculoskeletal system.^[44] Further, IA had a negative effect on mood states. Research has indicated that individuals with more severe IA have lower levels of social engagement and participation.^[45] Individuals who are vulnerable to IA reduce their contact and face-to-face communication with other people, which have been considered as stressors that could increase the risk of negative moods (such as anxiety, stress, and depression).^[46] Accordingly, we inferred that IA could have a double influence on physical and mental fatigue. We also considered several potential confounding factors, such as sex, age, BMI, smoking and drinking status, sleep duration and quality, and depressive symptoms. However, the associations between IA and fatigue after adjustment for these potential confounding factors remained significant.

5. Limitations

This study has several limitations. First, this observational study could not establish a causal association between IA and risk of fatigue. Second, this study only recruited regional college students from a single region, and the results may not be representative of all Chinese college students. Third, although the assessments of IA and fatigue showed good internal consistency and reliability, recall bias was inevitable owing to the subjectivity of the variables we measured. Fourth, the present study did not investigate their obligatory or elective courses status in the follow period during the semester, both of which are arranged more intensively in upper grades, and therefore could suffer from fatigue.^[47] Further studies are warranted to investigate these 2 kinds of course and examine whether these 2 kinds of course could confound the association between internet addiction and risk of fatigue. Finally, although we considered several potential confounding factors, we still could not completely account for the possibility that the association between IA and risk of fatigue was affected by other confounding factors such as healthy dietary habit (i.e., regular meal,^[6] adequate intake of eggs, fish, meat and beans; etc.^[48]) and academic stress,^[49] which all correlate with risk of fatigue.

6. Conclusion

The results of this study indicate that IA is positively related to risk of fatigue among Chinese college students. Further

interventional studies are needed to explore the causality underlying the effects of IA on fatigue.

Author contributions

ZR, GY: conceptualization and methodology. SL: formal analysis. SL: data curation. SL: writing—original draft preparation, review, and editing. All authors have read and agreed to the published version of the manuscript.

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